

RESEARCH DEPARTMENT

**ACOUSTIC TESTS IN BROADCASTING HOUSE, LONDON: THE ANOMALOUS SOUND
TRANSMISSION BETWEEN STUDIO S2 AND THE CONCERT HALL**

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ACOUSTIC TESTS IN BROADCASTING HOUSE, LONDON: THE ANOMALOUS SOUND TRANSMISSION BETWEEN STUDIO S2 AND THE CONCERT HALL

SUMMARY

This report describes investigations to ascertain the cause of excessive transmission of sound between the Concert Hall, Broadcasting House and Studio S2 which lies below it.

1. INTRODUCTION

The Broadcasting House control room, sited since 1939 in the sub-basement, was replaced in 1963 by a new control room in the Extension. The sub-basement site had originally been occupied by a studio used for plays and light music and on removal of the control room the decision was made for re-conversion into a light entertainment studio to be used mainly by small orchestras and "pop" groups. This is Studio S2.

When this new studio was being planned, possible interference by the noise of underground trains and from the Concert Hall above was considered, but in view of the nature of its probable use, it was not considered necessary to float the floor as a protection against the train noise, nor to increase the ceiling insulation beyond the measured average figure of approximately 60 dB.

There was a false ceiling to the control room and it was recommended by the Acoustics Committee that this ceiling should be retained. However, in the event, it was removed for reasons of building convenience, but its removal did not appear to make any serious systematic reduction in the insulation from the Concert Hall. Fig. 1 shows the measured sound level difference between the Concert Hall and the old control room area before and after the removal of the false ceiling of the control room.

Soon after Studio S2 went into service, it became the subject of complaints of interference with Concert Hall programmes. Sounds from S2 were occasionally transmitted loudly enough to distract musicians in the Concert Hall, though not enough to be heard on transmissions.

The sound appeared to be most freely transmitted in the neighbourhood of the front of the Concert Hall stage but listening gave no clear

indication of the direction from which the sound was coming. A thorough investigation was therefore undertaken.

2. LAYOUT AND CONSTRUCTION OF THE STUDIOS

Investigation of the transmission of sound was badly hampered by the absence of any structural drawings, the originals having apparently been destroyed by an air raid. The exact structure still remains a matter for inference since parts of the building are quite inaccessible. This applies particularly to a void above Studio S2, over which is supported the Concert Hall floor.

The two studios are bounded on the east and west sides by the side walls of the central studio tower. Being extremely massive, these walls are not driven into measurable vibration by normal sound pressures and therefore do not constitute a significant sound transmission path between the studios.

The end walls of Studio S2 are rather thinner and lie beneath the front part of the Concert Hall platform and the rear of the seating respectively. Fig. 2(a) is a plan of the Concert Hall at ground level; the positions of the end walls of S2 are indicated by dashed lines. Access to the void beneath the Concert Hall is through the lounge which lies beneath the control cubicle and it is possible to reach the space beneath the platform along the east wall, i.e. along the line AA' in Fig. 2(a). Fig. 2(b) is a sketch of the section of the building along AA'. Exploration was difficult as the height of the void varied from only 18 in. (450 mm) to 3 ft (0.9 m).

The seating of the Concert Hall is mounted on a 4 in. (100 mm) thick structure consisting of cement on Hy-Rib lathing pierced by 48 holes

which serve as ventilation extracts, the void being used as plenum chamber.

The seating floor is supported on a steel framework which rests near the front and the back on what appears to be upward extensions of the south and north walls respectively of S2. It is supported also by sleeper walls parallel to and about 5 ft (1.5 m) inside the side walls of the tower. The rear part of the platform is over a quiet area and so also is the rear of the seating.

There was a change in floor height between the extension of the south wall of S2 and a parallel unexplained formation approximately over the middle of S2. In the void, sounds from this studio appeared loudest over this raised section of the floor and particularly over the south wall of S2.

3. EXPERIMENTAL INVESTIGATION

3.1. General Considerations

From the above description of the construction it will be seen that the sound insulation between the two studios is provided basically by the main ceiling slab over S2 and the lighter floor of the Concert Hall, separated by a cavity varying in depth from 18 in. (450 mm) upwards. It is first necessary to consider whether the measured sound reduction between the studios was a representative value for such a construction or whether one would expect higher values. In the first case it would be unprofitable to spend time with experimental investigations, in the second there would be a possibility of discovering a fault in the design or construction which would account for the poor results.

Fig. 3 shows the result of such a consideration. Curve (a) is an estimated curve for the sound level difference between the Concert Hall and Studio S2 obtained by taking the average of one calculated curve and two measured curves from rather simpler constructions, the assumption being that they are separated by one 9 in. (230 mm) slab and a 4 in. (100 mm) slab mounted over an air space and pierced with the 48 ventilating holes described above. Curve (b) is the actual measured curve plotted at the same intervals of frequency. It will be seen that the measured curve falls on the average 11 dB short of the estimated curve. There is therefore a *prima facie* case for investigation.

3.2. Airborne Sound Reduction Measurements

Measurements were first made of sound level reduction between S2 and the cavity and between the cavity and the Concert Hall. The results are shown in Fig. 4, together with a curve representing

the sum of these two sound level differences. That between the cavity and the Concert Hall is in close agreement with the curve to be expected from the construction, after allowing for the effect of the holes, but the reduction between S2 and the void is lower than would be expected. Even so, the sum of the two is well above the measured curve for the reduction between the two studios.

From the apparently poor insulation of the main concrete slab, it is very probable that there is a transmission path parallel to that provided by the floor slab. From the further error when both skins are considered, it is to be inferred that this or some other flanking path also affects the insulation of the Concert Hall.

There remained a feeling in some quarters that the insulation could be made satisfactory by blocking up the 48 ventilating holes, and although it was already evident from the above measurements that improving the upper skin would not appreciably affect the total sound insulation, as it was probably limited by flanking transmission, it was decided to make a direct experimental test. The ventilation holes were temporarily sealed with 1 in. (25 mm) blockboard, which should have increased the sound reduction index of the skin to at least 45 dB, and measurements were repeated between S2 and the Concert Hall.

The results of these measurements are shown in Fig. 5. The difference between the two curves, though slightly in favour of the condition with the holes blocked, is within the limits of experimental error and certainly not great enough to account for the discrepancies being investigated or to reduce interference between the studios enough to prevent future complaints. Subjectively the blocking of the holes did not appear to make any difference to the sound transmitted from S2. Other possible paths of airborne sound transmission were investigated, including vertical cableways in the walls. Those going directly from the void to the Concert Hall were blocked for the tests on the effect of the ventilation holes but were in any case unlikely to be of importance. Subjectively there always appeared to be a slight increase of level of transmitted sound when approaching these cableways.

3.3. Structure-borne Transmission

In the absence of any discoverable major airborne sound transmission paths, the possibility of direct structure-borne transmission between the studios was investigated. It has been noted that in the Concert Hall, the transmitted sound appeared loudest in a strip across the hall including the front edge of the stage. An exploration was therefore

undertaken, using an accelerometer, to find out which surfaces of the Concert Hall were excited most strongly by sound from Studio S2.

Fig. 6(a) shows a plan view of the interior of the Concert Hall. Accelerometer readings, in dB above an arbitrary zero, are marked on the figure at various points on the floor; they were obtained by radiating constant-level warble tone at 500 c/s into S2 beneath and applying the accelerometer to the floor or to surfaces such as seat fixings which are rigidly connected to the floor.

The measured levels are highest along the front row of seats and the front of the stage, diminishing to below noise level about the ninth row of seats and falling by about 10 dB towards the back of the stage. At 250 c/s and 125 c/s, the distribution was very similar to this, whilst at 60 c/s the region of highest floor acceleration receded to about the fifth row of seats.

Fig. 6(b) is a section through the floor of the Concert Hall and the void. The south wall of S2 is also indicated. The highest accelerations on the floor of the void were found in the neighbourhood of the top end of the wall of S2 though the fall-off in level is less rapid than in the floor above. High amplitudes of vibration were also found on the sleeper wall supporting the floor, and these diminished with distance from the south wall of S2, though again rather slowly.

Acceleration amplitude levels measured on the surfaces of the south wall, four to six feet (1.2 m to 1.8 m) above S2 floor level, are also shown in Fig. 6(b). They are up to 16 dB higher than those measured on the floor of the void or on the sleeper wall, a difference which is consistent with previous measurements of the attenuation of sound in passing along masonry walls.

There seems little doubt, therefore, that the sound is transmitted primarily up this wall and into the structure supporting the floor of the Concert Hall, from which it is radiated into the air. The absolute values of the acceleration amplitudes of the floor are in good agreement with those required to produce the measured sound levels in the Concert Hall, suggesting that this explanation is sufficient to account for the whole sound transmission.

One feature which is not explained is the continuous reduction of vibration level towards the back of the Concert Hall. There is no obvious difference between the south and north walls of S2 or the method of mounting the floor of the Concert Hall over them, yet the acceleration levels on the Concert Hall floor over the north wall is below random noise level. The explanation must lie in the structural details, particularly of the raised section of the floor of the void which, as mentioned in Section 2 above, are not fully known.

4. CONCLUSIONS AND RECOMMENDATIONS

1. There is no ascertainable path of airborne sound transmission to account for the low sound insulation of the Concert Hall from Studio S2.
2. Sound leakage takes place from the south wall of S2 directly through the supporting structure to the seating area of the Concert Hall.
3. The maximum transmission is in the region of the south wall of S2. The north wall does not appear to contribute significantly, though the reason for this difference could not be discovered.
4. The leakage could be reduced only by interrupting the transmission from the S2 wall to the Concert Hall floor. Only a full exploration by Building Department will establish whether this is feasible.

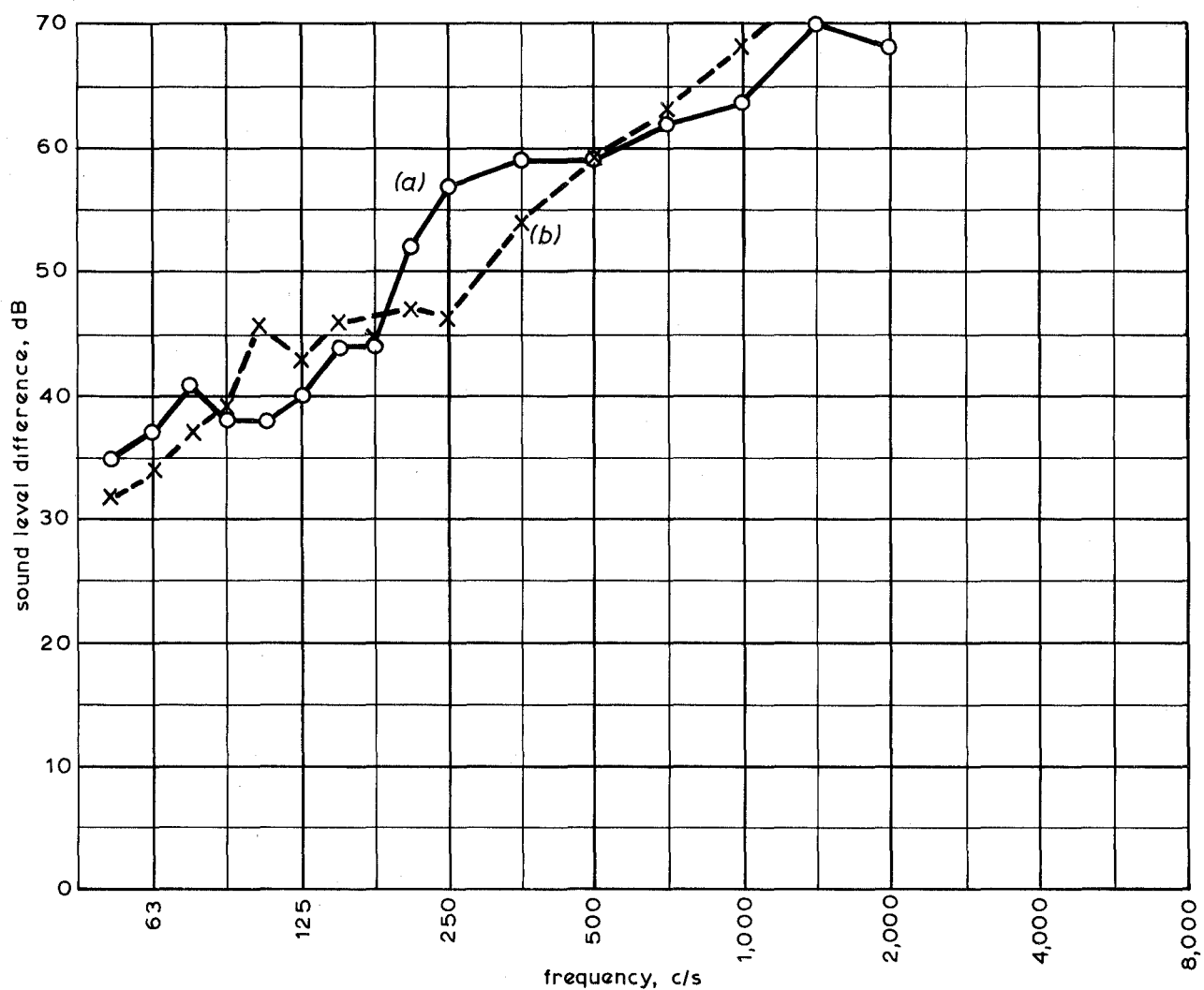
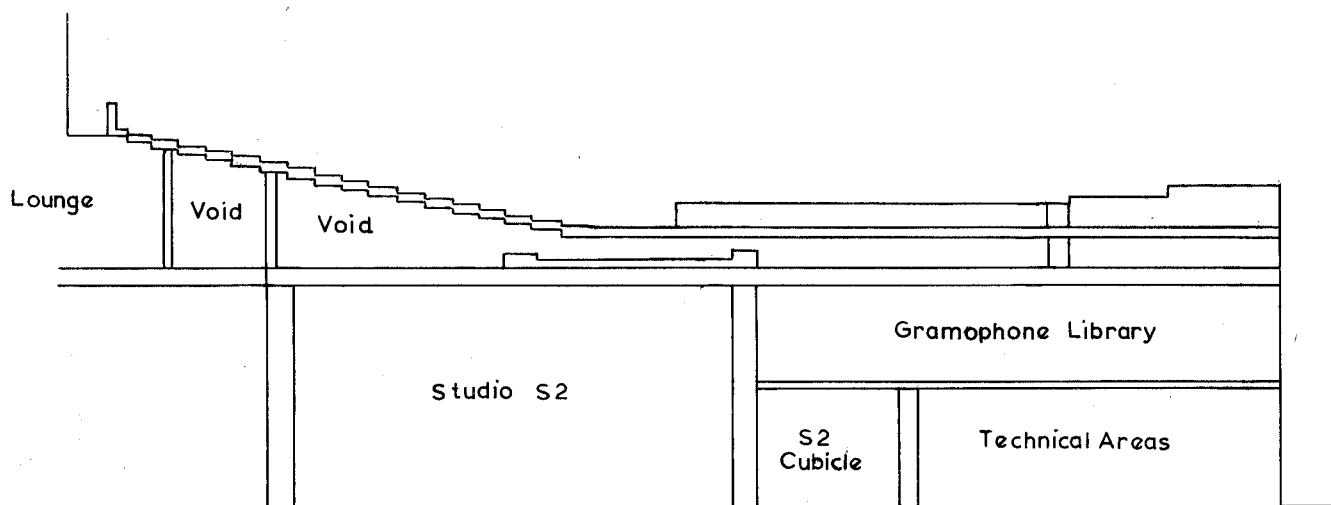


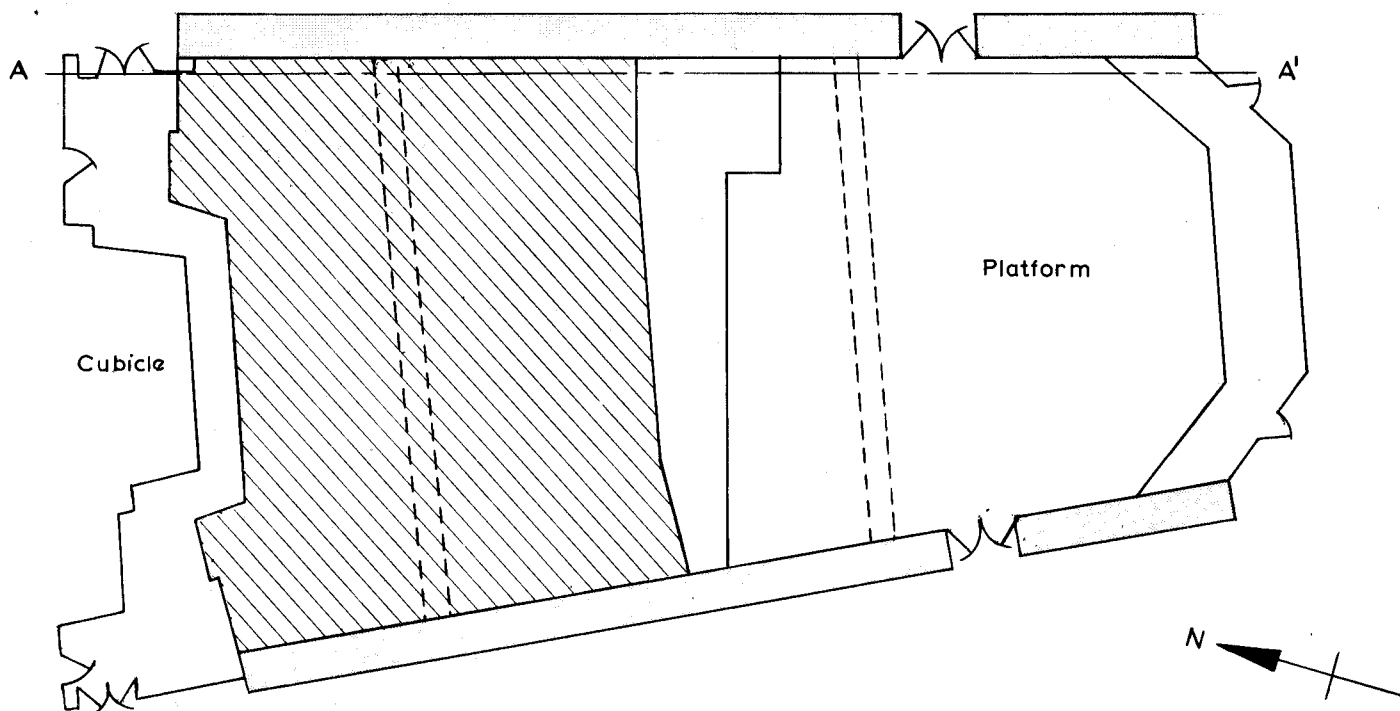
Fig.1 Sound insulation between the Concert Hall and the site of S2.

(a) Original state.

(b) After removal of the false ceiling.



(b) Long section through A A'
(not to scale)



(a) Plan through ground floor level. Dashed lines indicate walls of S2.

Fig. 2 Plan and section of part of Broadcasting House showing structure between the Concert Hall and Studio S2.

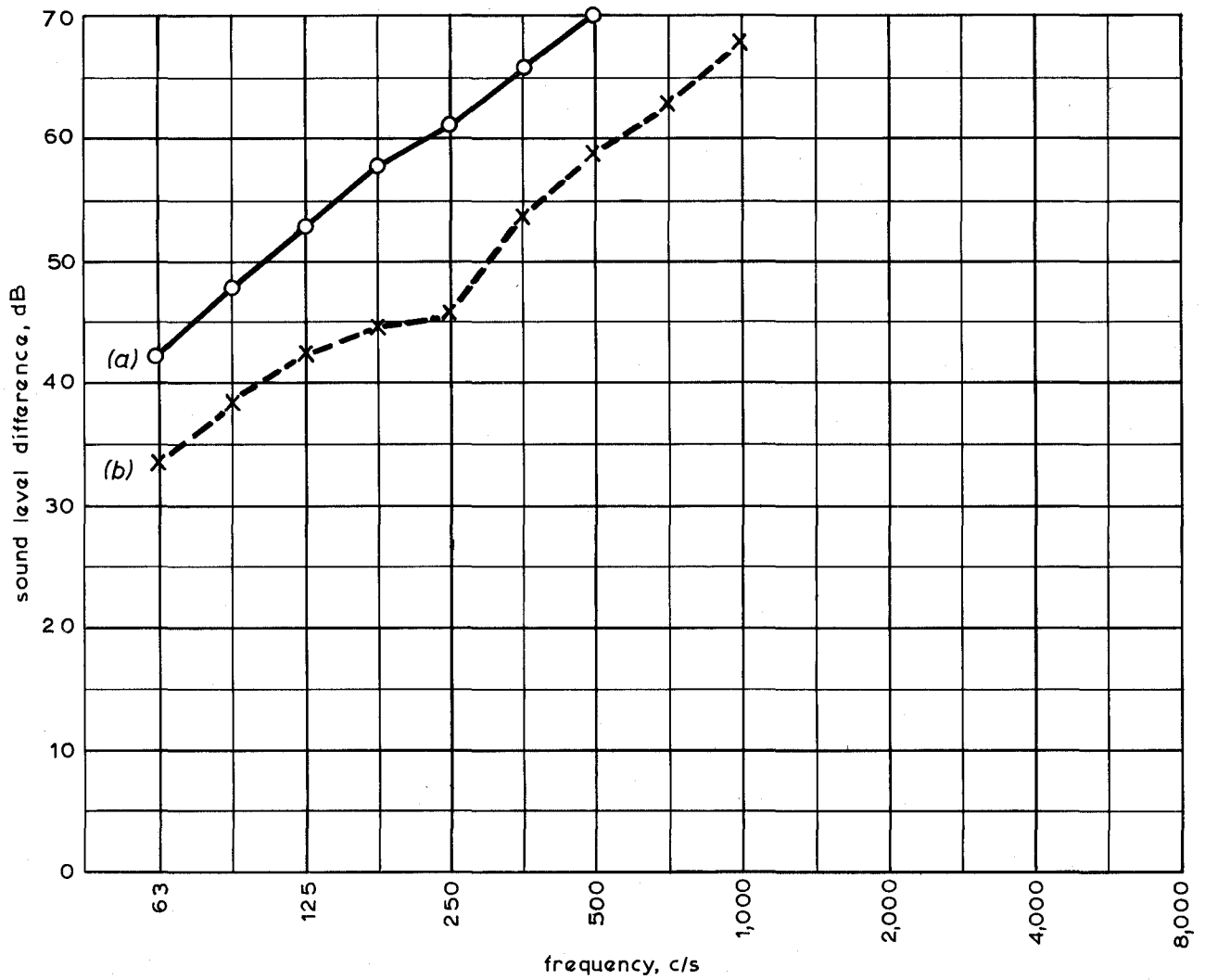


Fig. 3 Measured and estimated sound level difference between Concert Hall and Studio S2

- (a) Estimated by calculation and comparison with similar constructions.
- (b) Measured sound level difference.

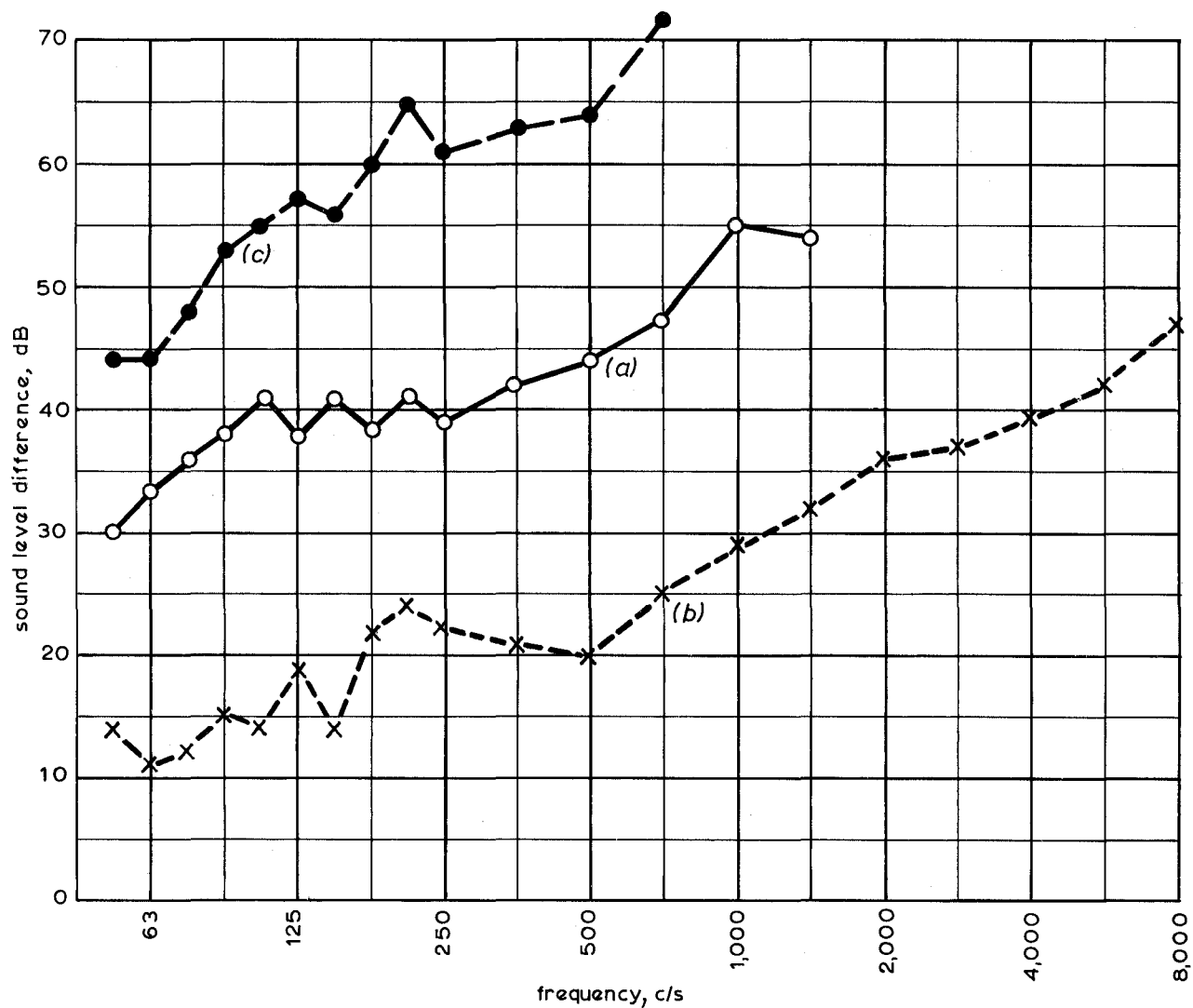


Fig. 4 Measured sound level reduction between cavity and studios above and below.

- (a) Between Studio S2 and cavity.
- (b) Between cavity and Concert Hall.
- (c) Sum of above two.

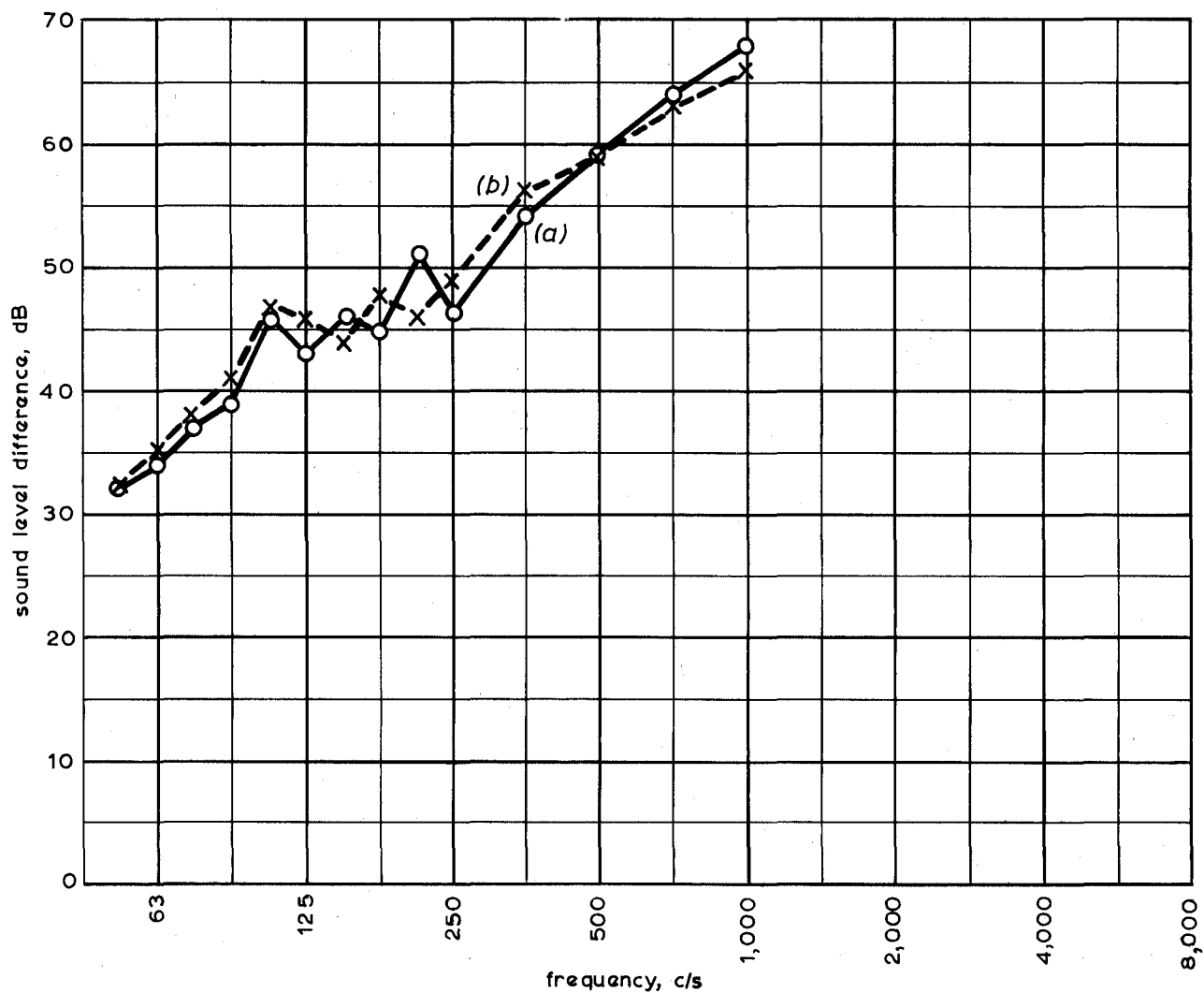


Fig.5 Sound level difference between Concert Hall and Studio S2:
Effect of Blocking ventilating holes in the Concert Hall floor.

- (a) Holes open.
(b) Holes blocked.

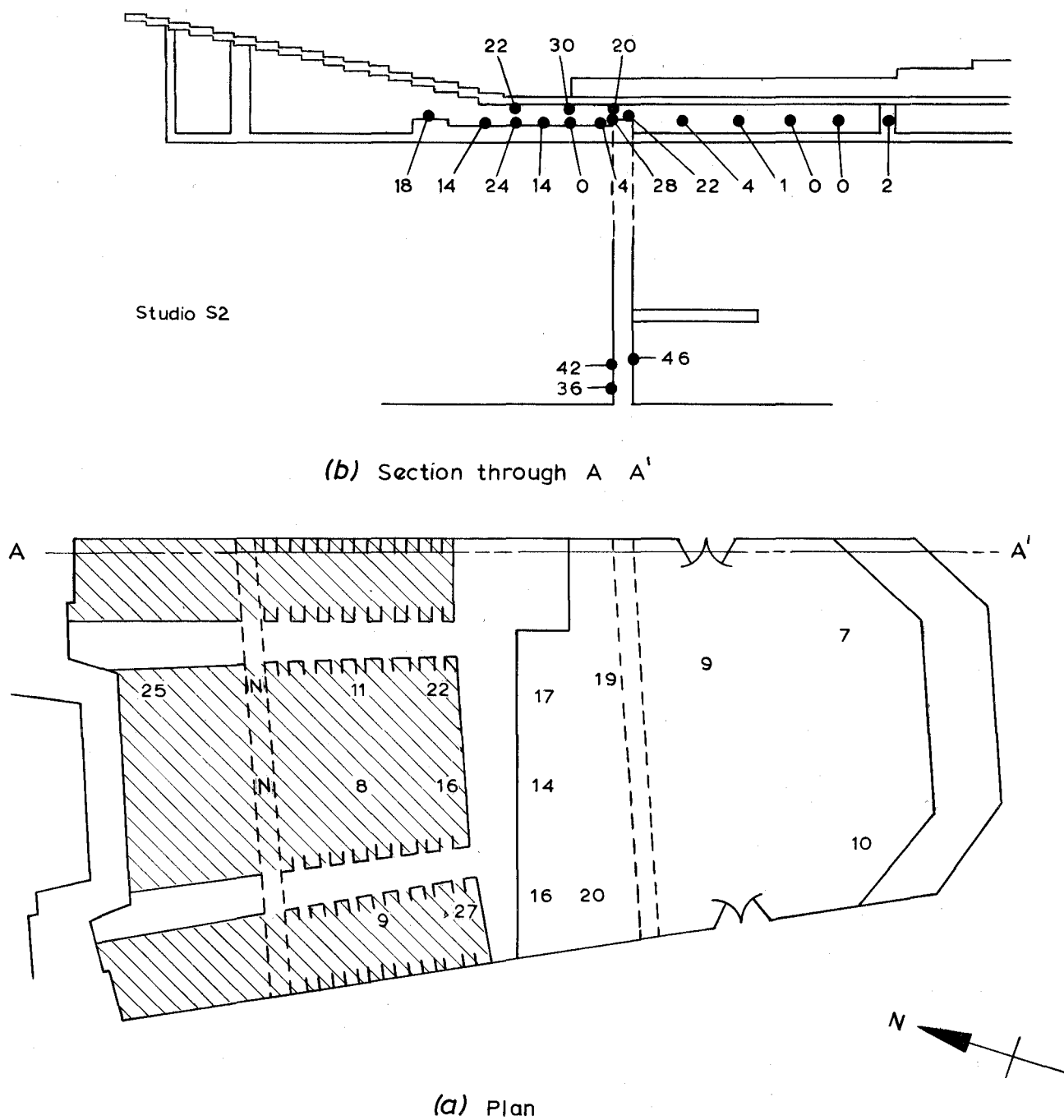


Fig.6 (a) Plan and (b) section of Concert Hall and void showing acceleration level distribution.

Figures are in dB above arbitrary zero.
N indicates below noise level.

